Evidence of the magnetotelluric 3-D inversion ability to account for static shift effects: A comparison between MT and heliborne TEM

Nicolas Coppo, Sophie Hautot, Pascal Tarits

Evidence of the magnetotelluric 3-D inversion ability to account for static shift effects: A comparison between MT and heliborne TEM

[1]Coppo N., [2]Hautot S. and [3]Tarits P.
[1]Bureau de Recherches Géologiques et Minières, 3 av. Claude Guillemin, BP 36009, 45060 Orléans Cedex 2, n.coppo@brgm.fr.
[2]IMAGIR, Technopôle Brest-Iroise, Institut Universitaire Européen de la Mer, Site de la Pointe du Diable, Place Nicolas Copernic, 29280 Plouzané, Sophie.Hautot@imagir.eu.
[3]Université de Bretagne Occidentale, Technopôle Brest-Iroise, Technopôle Brest-Iroise, Institut Universitaire Européen de la Mer, Site de la Pointe du Diable, Place Nicolas Copernic, 29280 Plouzané, tarits@univ-brest.fr.

SUMMARY

Within the framework of a global French program towards development of renewable energies, Martinique Island (Lesser Antilles, France) has been extensively investigated (from 2012 to 2013) through an integrated multi-disciplinary approach, with the aim to identify precisely the potential geothermal resources previously highlighted (Gadalia et al., 2014). Among the investigation methods deployed (geological, geochemical and hydrogeological), we carried out three magnetotelluric (MT) surveys above three of the four most promising areas of Martinique, namely the Anses d'Arlet, the Montagne Pelée and the Pitons du Carbet prospects. A total of about 100 MT stations were collected in the frequency range 1000 Hz to 10^{-2} Hz together with TEM soundings for potential static shift correction. 3-D MT inversions of the full tensor were run on each sector which took into account the coast effect. Assuming that the static shift observed is the result of near-surface lateral inhomogeneity causing electric field distortion, it can be accounted for by the inversion scheme used by Hautot et al. (2000, 2007) and no prior static correction was applied before inversion. The model results show that most of the soundings displaying static shift effect are accurately reproduced by near-surface resistivity distribution in the model. However it is generally difficult to prove that the shallow structures explaining the static distortion obtained by the MT inversion are real features at the scale of the survey. Here we consider additional high resolution geophysical data to overcome this problem.

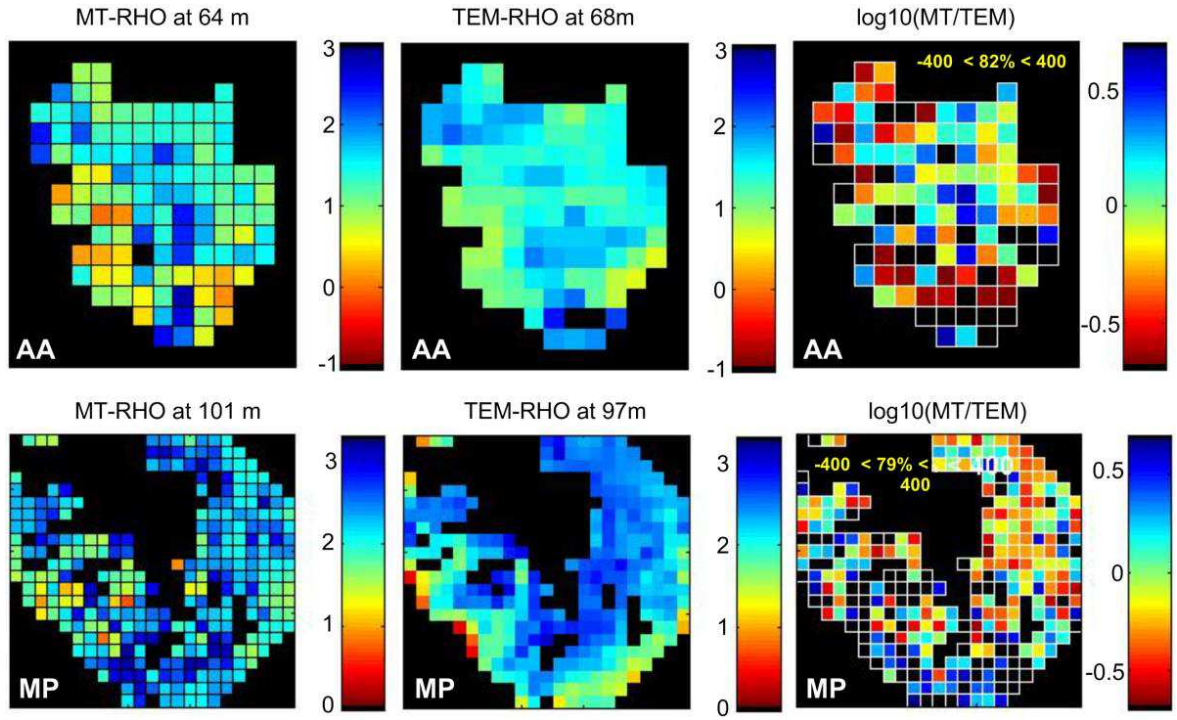

Figure 1. MT versus TEM resistivity for superficial layers. Above are represented the data of the Anses d'Arlet (AA) geothermal province and below from the Montagne Pelée (MP) geothermal province. Left plots display resistivity from the 3-D MT models for both sector at the indicated depth. Center plots display resistivity of the TEM data (see text for details). Right plots show variation between the two models (log scale).

We demonstrate with the help of the results from the recent heliborne TEM survey covering the whole Martinique (marTEM project) that the sub-surface resistivity distribution obtained from 3-D MT inversion reproduces faithfully the resistivity distribution observed by TEM data (Figure 1). Data of two of the three investigated sectors (Anses d'Arlet and Mount Pelée geothermal provinces) are presented because there is a sufficient spatial density of MT soundings. To compare both datasets, TEM data were first homogenized over the investigated area by krigging the resistivity distribution by layer. The median resistivity of this new grid is then extracted above each cell of the MT model and compared to the MT resistivity. Cells that do not contain TEM information or are located too far away from the fly lines are removed from the statistics. The results show that 82% of the cells considered have a maximum resistivity variation below 400% for the Anses d'Arlet prospect and 79 % for the Montagne Pelée. Thus despite a widely different sampling scale between the two sets of data (53 MT soundings,> 20000 TEM for the Mount Pelée and 32 MT soundings, >6200 TEM), the comparison between the two near surface resistivity models illustrates the ability of our inversion scheme to take into account and reproduce static shift effects.

Keywords: Magnetotelluric, static-shift, 3-D inversion, TEM, Martinique

REFERFENCES

Gadalia A, Baltassat JM, Bouchot V, Caritg S, Coppo N, Gal F, Girard JF, Gutierrez A, Jacob T, Martelet G, Rad S, Tailame AL, Traineau H, Vittecoq B, Wawrzyniak P, Zammit C (2014) Compléments d'exploration géothermique en Martinique : synthèse et recommandations pour les zones de la Montagne Pelée, des Anses d'Arlet, des Pitons du Carbet et du Lamentin. Rapport final BRGM/RP-63019 -FR, 227 p, 75 fig., 7 tabl., 4 ann., 1 CD.

Hautot S, Tarits P, Whaler K, Le Gall B, Tiercelin JJ, Le Turdu C (2000) The deep structure of the Baringo Rift basin (central Kenya) from 3-D magneto-telluric imaging: Implications for rift evolution. Journal of Geophysical Research 105: 23493-23518.

Hautot S, Single R, Watson J, Harrop N, Jerram DA, Tarits P, Whaler KA (2007) 3-D magnetotelluric inversion and model validation with gravity data for the investigation of large igneous provinces. Geophysical Journal International 170(3):1418-1430.